Thoughts on Tone and Embouchure

"Everything affects everything" – David Williams, flute maker.

The subject of the quote was the myriad of options available on flutes in terms of the materials of manufacture, such as tubing material, thickness, head and riser material, riser shape and cut, even style and configuration of stopper.

This applies to tone as well.

The most important factor in the sound of the flute remains your own body: your facial muscles, your lips, teeth, tongue, shape and size of the oral cavity, your throat and voice box, your chest cavity, the strength and flexibility of the "breathing" muscles (the opposing muscle groups of the abdominals / diaphragm and the interior and exterior intercostals, which control the air pressure). Most of these factors can be varied by the flutist so some degree, and, in some cases, independently of all of the others.

The Flute: An Air-Reed Instrument

It is important to understand clearly where the flute tone comes from. In the simplest terms, a funnel of air, formed and directed by the lips, strikes the outer edge of the blowhole. This briefly compresses the air in the tube. The air, being elastic, bounces back, pushing back at the air funnel. The pressure of the funnel overcomes this pushback and compresses the air in the tube again. This seesaw motion, if continued, sets up a regular oscillation in the funnel, which in turn excites a regular compression / decompression cycle in the tube, thus forming a standing wave inside it. This standing wave is the tone of the flute. The oscillation of the air funnel is why the flute is called an "air reed", in that it acts in a way similar to the reed on a clarinet or bassoon, i.e., its motion creates a standing wave inside the tube of the instrument.

The flute differs in an important way from cane-reed wind instruments, in that for the most part it lacks octave keys. The sounding tube continues to vibrate at its fundamental pitch (which is the first partial), determined by its length, until something happens to cause it to split into two and vibrate at the second or subsequent harmonic.

The question is, what makes the flute jump up to the next harmonic? The simple answer is that the air-reed is made to oscillate faster and faster until the standing wave is forced to jump to the next harmonic, *since the tube vibrates sympathetically*, or in conjunction with, the air-reed. An octave key on an oboe, on the other hand, will force the upper harmonic to sound because it creates a point of low pressure in the tube that causes the vibrating column to split at or near that point. The reed always, or nearly always, vibrates at the same speed. This gives rise to certain intonation problems with cane-reed instruments that the flute doesn't share, such as the tendency to blow flat at higher dynamic levels. The flute, of course, does the opposite. More about that later.

The key question, then, is, how do you make the air-reed vibrate faster in order to sound the next harmonic? By making the air go faster. In going to the next higher harmonic, the air speed is gradually increased, until a critical point is reached in which the sounding tube starts vibrating sympathetically at the next highest harmonic. In the reverse direction, the air slows until a critical point is reached when the sounding tube reverts to the next lower harmonic.

An important point is to observe what happens to the pitch of the note as the air speed increases, but before it jumps to the higher harmonic: it goes up. Slowing the air, the pitch goes down. *Both pitch and register are controlled by air speed.*

In practice, the register change in air velocity is made very quickly, so as to minimize its effect on pitch.

These simple mechanics don't tell the whole story, however, because several variables influence the speed of the air. Among them are: the air angle, the size and shape of the opening formed by the lips, the presence or absence of various obstructions (teeth, tongue, closed throat, etc.), and the overall pressure with which the air is applied to the instrument by the breathing system.

Air striking a flat surface behaves like a fluid. Take a garden hose and direct a stream of water at the sidewalk, and observe the difference in the distance the water splashes when directed at an acute angle vs. an oblique one. Note that constricting the flow with your thumb makes the water come out faster, but so does turning up the water at the tap, *up to a point.*

Given equal pressure, making the embouchure opening smaller will increase the speed of the air. Again given equal pressure and opening size, increasing the angle (blowing down) will slow the air, blowing up will speed it up. . Both of these mechanisms will, in addition, change the volume of air that contributes to the air-reed, thus making the sound louder or softer. *Dynamics are controlled by air volume.*

An important question raised by the mechanical discussion above is: how is the air controlled? Most of the control comes from the embouchure, or the formation of the lips.

The Lips: An Air Valve

The lips are formed into a *valve* for controlling the air, using several groups of facial muscles. The valve can open, close, become wider, narrower, taller, shorter, be directed up, down, and, to a lesser extent, from side to side. Usually these changes are made in combination with each other.

The "valve" is formed by a group of muscles in the face called the "muscles of expression."

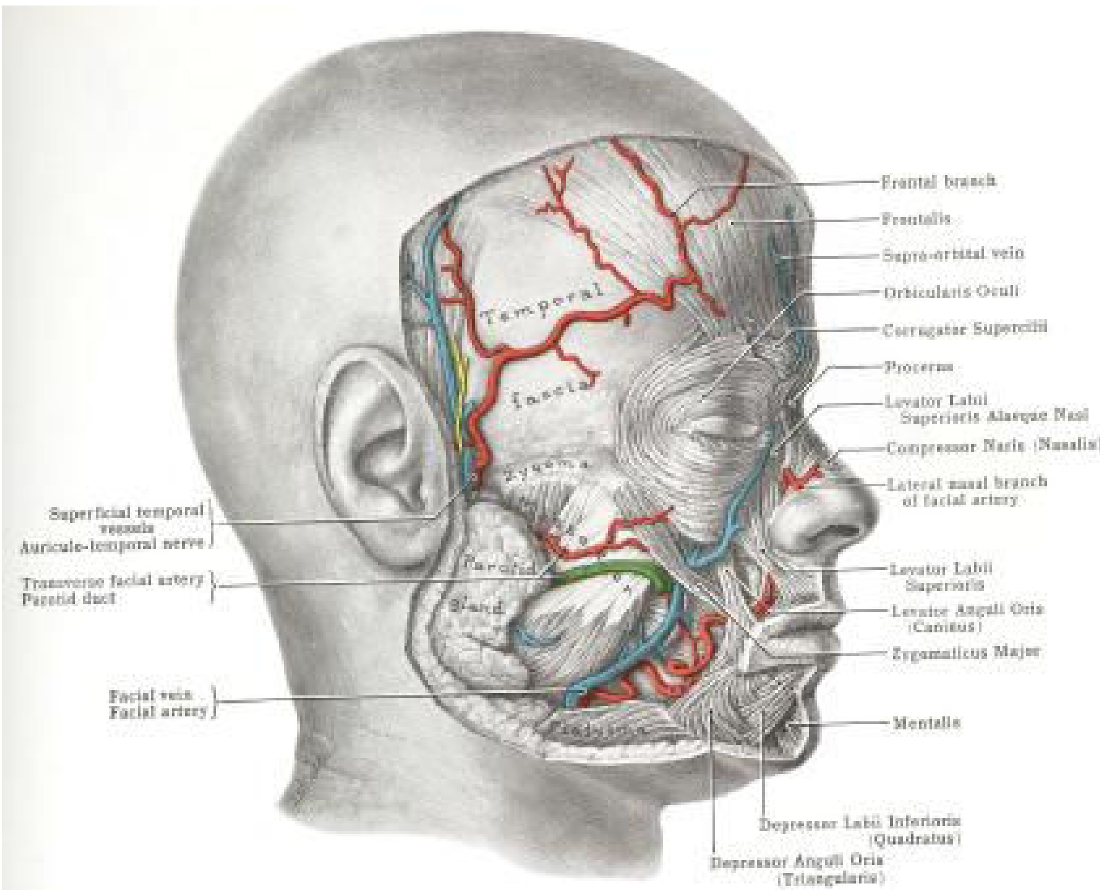

Figure 1: Facial Muscles, side view

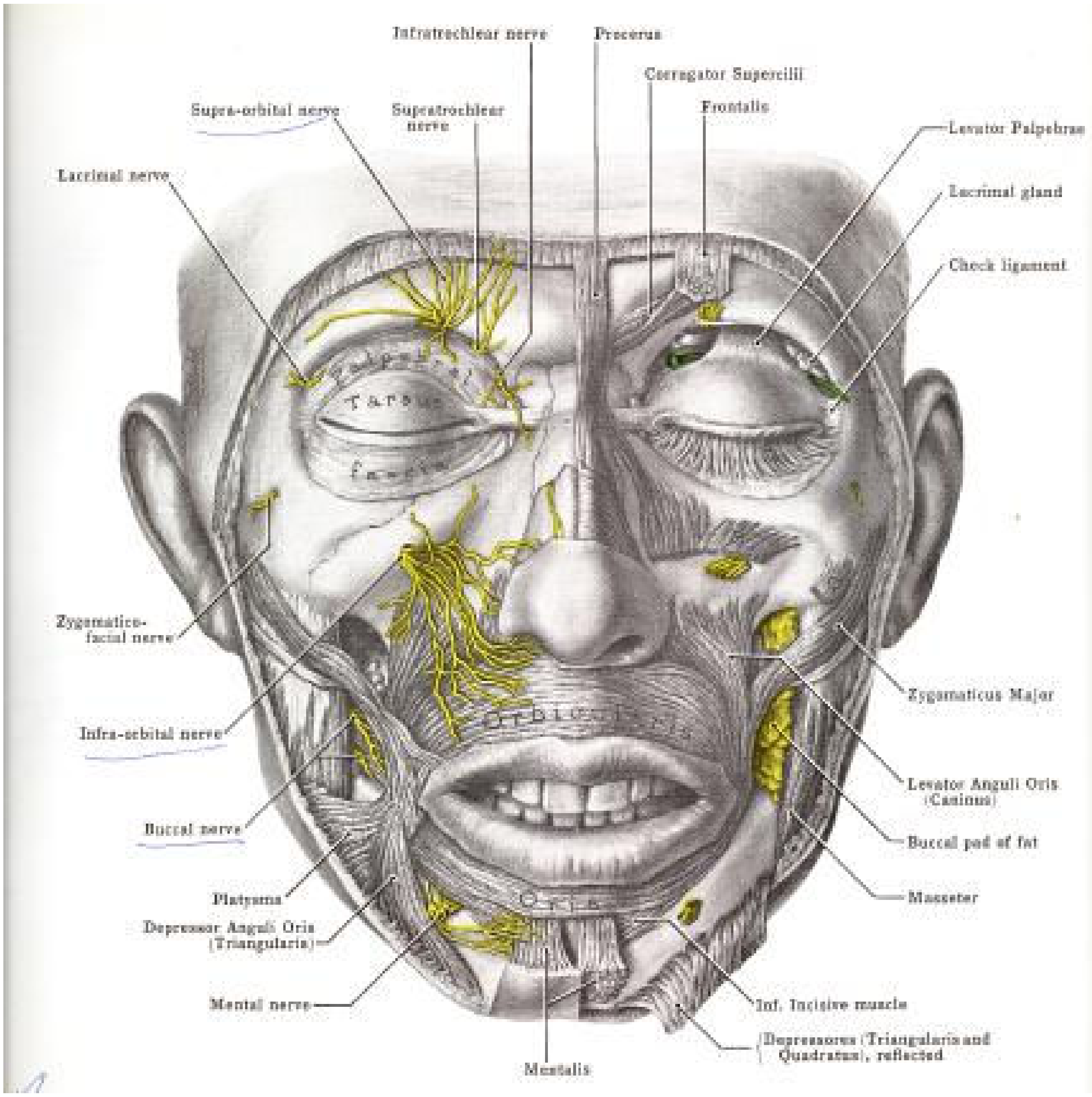

Figure 2: Facial Muscles, front view

Considered independently, the most important muscle groups do the following:

Orbicularis Oris	Pursing the lips
Mentalis	Extending lower lip
Levator Labii Superioris	Pulling up the upper lip
Levator Anguli Oris	Tighten the corners of the mouth
Depressor Anguli Oris (Triangularis)	Pull down the corners of the mouth
Zygomaticus Major	Widen the upper lips (e.g., the Mona Lisa)
Depressor Labii Inferioris (Quadratus)	Widen the lower lip and pull it down

These muscles, which are for the most part are branches of a large muscle originating in the chest called the Platysma (which extends halfway up the face), as well as some others not mentioned, perform these operations in concert with each other. For example, the Zygomaticus Major and the Quadratus work together to pull the lip down.

Extending the upper and lower lips while maintaining tension in the Orbicularis Oris presses the lips together, making the opening smaller (i.e., closing the valve). This same motion performed while relaxing the Orbicularis Oris presses the lips forward without changing the size of the opening. Either motion can change the angle of the air funnel, depending on how much if any the lips extend or retract with respect to each other.

Slightly widening the lips, especially the upper one using the Zygomaticus Major, widens the opening between the lips. This has the effect of increasing volume of air (assuming pressure is also increased to compensate for increased size) and forming an air funnel that is wider when it strikes the outer edge of the blowhole. In effect, the air-reed is enlarged. The Obicularis Oris must also be relaxed somewhat, to allow the opening to widen without becoming too tall. This results in a more complex timbre than that achieved with a narrower opening. Returning to the cane-reed analogy, this is similar to using a harder (i.e., thicker) reed. It vibrates more loudly and strongly, but at the same time is harder to control.

Modern flute heads are designed, for the most part, to be played with a "harder" air reed.

Other Valve Controls

Other mechanisms are used, in combination with the muscles of expression, to control and direct the air-valve. The jaw can be raised and lowered to direct the air stream up and down. This is not done for register control, but to counteract the natural tendency of the low notes to be flat and the upper notes to be sharp, and to color the sound. If the jaw is lowered (the lips rotating to provide a constant opening size), the pitch will be lowered somewhat due to the increased angle of the air funnel. If the jaw is raised, the pitch will be raised, due to the decreased angle. The jaw movements are secondary to and extend the motions of the lips in changing the angle.

Because the overhang of the upper lip and the blowhole coverage of the lower lip vary when the jaw is moved, sometimes a marked change in the quality or color of the sound is noted. The change consists in increasing or decreasing the strength of the second through the fourth harmonics. To experiment with this, over blowing harmonics using the lowest notes on the flute is invaluable practice. Note the subtle lip tensions and balances needed to produce the second harmonic (an octave and a fifth above the fundamental), and utilize them while sustaining a note.

Another mechanism for practicing the subtle muscle interactions used in playing with refined tone control is whistle tones. The whistle tone is made by the air reed vibrating into the blowhole without causing the tube to vibrate. A very small volume of air is necessary. Isolating individual tones, not to mention playing controlled arpeggios, is an excellent way to discover and refine the subtle muscular control required for fine tone control.

Note that the whistle-tone is the equivalent of a cane-reed player buzzing the reed, or of a buzz-reed (i.e., brass) player buzzing the mouthpiece. Actually buzzing the lips is not recommended under any circumstances since its mechanism is not similar to the flute embouchure. Besides, it numbs the lips. It conditions the player to blow against the resistance of the buzz-reed, which is good, but high harmonics are a better exercise for flutists to practice blowing against resistance.

Beyond the Embouchure

The tone begins where the air begins: with the chest and lungs. Like the voice, the chest resonates when the flute is played; therefore the full expansion of the chest, especially in back, is key to enabling this tone and projection enhancing resonance[1]

The throat, because the Platysma muscle extends over it and tends to tense sympathetically with the embouchure, tends to become tight and constricted *above* the larynx, especially when the vibrato is centered there. The larynx itself, which can only stretch open, cannot be constricted except indirectly, from the throat above.

The mouth is open, the teeth are held apart, and the tongue is formed into a flat conduit for initiating the air funnel. It is not held up in the middle of the mouth and pointed (as if about to say "la" or "ra", since this obstructs the air originating from the lungs. The primary syllable of articulation is the tongue tapping the lip at the ends of the upper teeth, since this deforms the mouth the least and creates the least turbulence.

The whole breathing apparatus, including the air conduits formed by the throat and mouth, is used in such a way as to maximize control over the volume and pressure of the air being delivered to the "air-valve": open and relaxed, as well as big and powerful.

Beyond Tone

There is no such thing as a "flute tone" that exists independently of music. The sound of the flute has no more meaning than the ringing of the telephone or the screeching of brakes. It is when it is placed in the context of a musical phrase that the sound of the flute, in all its color and variety, can have meaning, and that meaning is an entirely musical one. Unless the sound of the flute contributes to communication of a musical phrase, a musical idea, a sense of motion to or from something, a sense of suspension, or other musical archetype, the flute might as well remain in its case, silent.

Discussions of which sound is "better" than another have no meaning outside a musical context, too, because there is no sound that the flute can make which is not appropriate for one musical context or another. The flutists' search is always for that sonority which provides for the most effectively communicated musical statement, for which there are more "correct" answers than there are stars in the sky. Experience, however, coupled with a keen musical intelligence, enables the flutist to make engaging choices.

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[1] . A detailed discussion of the breathing mechanisms is beyond the scope of this article.